

## **SECTION 15950**

### **CONTROLS**

#### **1PART - GENERAL**

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##### **2.1 Related Documents**

- A. All sections of Division 1.
- A. Examine all drawings and all other Sections of the Specifications for requirements therein affecting the work of this Section. Work shall be coordinated with other trades prior to installation to prevent interference and relocations.

##### **1.1 Summary**

- B. Analog control equipment.
- B. Digital Control equipment.
- B. Software.
- B. Air supply system.
- B. Instruments and control elements.
- A. Sequence of operation.

##### **1.2 SYSTEM DESCRIPTION**

- B. Control Systems: Thermostats, control valves, dampers and operators, indicating devices, interface equipment and other apparatus and accessories required to operate mechanical systems, and to perform functions specified.
- A. Automatic Temperature Control Systems: Pneumatic with electric accessories.

\*\*\*\*\* [OR] \*\*\*\*\*

C. Automatic Temperature Control Systems: Distributed system of intelligent, stand-alone controllers, operating in multi-tasking, multi-user environment on network, with central and remote hardware, software, and interconnecting wire and conduit [with communications to Building Management System specified in Section 13805].

C. Include computer software and hardware, operator input/output devices, control units, local area networks (LAN), sensors, control devices, actuators.

C. Controls for variable air volume terminals, radiation, reheat coils, unit heaters, fan coils, and the like when directly connected to the control units.

C. Include installation and calibration, supervision, adjustments and fine tuning necessary for complete and fully operational system.

## 2.4 SUBMITTALS

B. Shop Drawings: For review indicate complete operating data, system drawings, wiring diagrams, and written detailed operational description of sequences.

1. Include trunk cable schematic showing programmable control unit locations, and trunk data conductors.
2. List connected data points, including connected control unit and input device.
3. Include system graphics for monitored systems, indicating data (connected and calculated) point addresses, and operator notations.
4. Show system configuration with peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
5. Label with settings, adjustable range of control and limits. Include written description of control sequence.
6. Include flow diagrams for each control system, graphically depicting control logic.
7. Include description and sequence of operation of operating, user, and application software.
8. Submit schedule of valves indicating size, flow, and pressure drop for each valve.
9. For automatic dampers indicate arrangement, velocities, and static pressure drops for each system.

B. Product Data: For review provide description and engineering data for each control system component. Include sizing as requested. Provide data for each system component and software module.

B. Operation and Maintenance Instructions: For project closeout include:

1. Systems descriptions, set points, and controls settings and adjustments.
2. Inspection period, cleaning methods, recommended cleaning materials, and calibration tolerances.
3. Interconnection wiring diagrams complete field installed systems with identified and numbered, system components and devices.
4. Keyboard illustrations and step-by-step procedures indexed for each operator function.

## 2.3 MAINTENANCE

- B. Provide [manufacturer's] maintenance services on control system for [one] [ ] year from Date of Substantial Completion.
- B. Include complete service of controls systems, including call backs. Make minimum of [ ] complete normal inspections of approximately [ ] hours duration in addition to normal service calls to inspect, calibrate, and adjust controls, and submit written reports.
- B. Furnish [two] [ ] of [printer ribbons] [cartons of printer paper] [ ].

## 2 PART - PRODUCTS

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### 3.3 SYSTEM MANUFACTURERS

- B. Manufacturers:
  1. [ ] Model [ ].
  2. [ ] Model [ ].
  3. [ ] Model [ ].

### 2.3 PNEUMATIC SYSTEM COMPONENTS

- B. Receiver Controllers: Single or dual input models with mechanical set point adjustment, proportional band adjustment, and authority adjustment; [proportional] [proportional plus integral] control mode.
- B. Pneumatic Systems Accessories
  1. Pressure Gages: Black letters on white background, 2 inch (50 mm) diameter, flush or surface mounted, with front calibration screw.
  2. Diaphragm Control and Instrument Valves: 1/4 inch (6 mm) forged brass body with teflon diaphragm, stainless steel spring, and phenolic handle.
  3. Gage Cocks: Tee or level handle, bronze, rated for 125 psig (860 Kpa).
  4. Relays: For summing, reversing, amplifying, highest or lowest pressure selection, with fixed 1:1 [or adjustable] input/output ratio.
  5. Switches: With indicating plates, accessible adjustment.

### 2.3 ANALOG ALARM SYSTEM

- B. Provide alarm panel with individual indication, horn, silenced acknowledge switch, and test switch.
- B. At any alarm condition indication light will flash and alarm will sound. Stop horn by depressing acknowledge switch and indicate alarm conditions by a continuous light until trouble condition has cleared. Sound alarm again should second alarm occur before first one has cleared.

- B. Provide dry contacts at main alarm panel for use by independent alarm monitoring company to activate each alarm condition.

## 2.3 DIGITAL CONTROL EQUIPMENT

### B. Operator Work Station:

1. Configuration: IBM compatible [80486] [ ] based microcomputer system or better.
2. Minimum memory: [4] [ ] Mb RAM.
3. Memory clock speed: [33] [50] [66] [ ] Mhz.
4. Cache memory: [128] [256] [ ] kbyte.
5. Display: Super video color graphics adapter (SVGA), 14 inch (350 mm) non-interlaced color monitor, maximum 0.28 mm dot pitch.
6. Keyboard: Low profile, detachable, having Qwerty layout plus a 10 key numeric keypad, dedicated function keys.
7. Floppy disk drive: [1.2 Mb] [and] [1.44Mb].
8. Hard disk drive: [105] [ ] Mb.
9. Mouse: Software supported mouse with support software including self building menus and displays of system operations and functions.
10. Modem: [Internal] [External] type modem or proprietary data modem with cables and communication interfaces required to provide the specified functions, minimum [14,400] [ ] bps rate.
11. Printer: Support color printer.
12. Operating System: [MS-Dos 5.0 or higher] [ ].

### B. Printer:

1. Wide carriage with 132 characters per line using fan-fold paper.
2. Minimum operating speed of [120] [ ] characters per second.
3. Paper: [Two] [ ] cartons fanfold paper containing minimum 2500 sheets.

- B. System Support: Minimum ten (10) work stations connected to multi-user, multi-tasking environment with concurrent capability to access DDC network, develop and edit data base, and control facility.

### B. Control Units

1. Units: Modular in design and consisting of processor board with programmable RAM memory, local operator access and display panel, and integral interface equipment.
2. Battery Backup: For minimum of [48] [100] hours for complete system including RAM without interruption, with automatic battery charger.
3. Control Units Functions:
  - a. Monitor or control each input/output point.
  - b. Independent with hardware clock/calendar and software to maintain control independently.
  - c. Acquire, process, and transfer information to operator station or other control units on network.
  - d. Accept, process, and execute commands from other control unit's or devices or operator stations.

- e. Access both data base and control functions simultaneously.
    - f. Record, evaluate, and report changes of state or value that occur among associated points. Unit shall continue to perform associated control functions regardless of status of network.
  - 4. Input/Output Capability:
    - a. Discrete/digital input (contact status).
    - b. Discrete/digital output.
    - c. Analog input.
    - d. Analog output.
    - e. Pulse input (5 pulses/second).
    - f. Pulse output (0-655 seconds in duration with 0.01 second resolution).
  - 5. Install control unit's with minimum [30] [ ] percent spare capacity.
  - 6. Test Mode Operation: Place input/output points in test mode to allow testing and developing of control algorithms on line without disrupting field hardware and controlled environment.
- C. Local Area Networks (LAN):
- 1. Provide communication between control units over local area network (LAN).
  - 2. LAN Capacity: Not less than [60] stations or nodes.
  - 3. Transmission Median: Fiber optic or single pair of solid 24 gauge twisted, shielded copper cable.
  - 4. Network Support: Time for global point to be received by any station, shall be less than 3 seconds. Provide automatic reconfiguration if any station is added or lost. If transmission cable is cut, reconfigure two sections with no disruption to system's operation, without operator intervention.
- B. Operating System Software
- 1. Input/Output Capability From Operator Station: Display current values or status, command equipment, initiate logs and reports, add, delete, or change points or descriptors, develop or modify color graphic displays, automatically archive select data.
  - 2. Operator System Access: Via software password with minimum [30] [ ] access levels at work station and minimum [3] [ ] access levels at each control unit.
  - 3. Data Base Creation and Support: Utilize standard procedures. Control unit shall automatically check work station data base files upon connection and verify data base match.
  - 4. Dynamic Color Graphic Displays:
    - a. Utilizes custom symbols or system supported library of symbols.
    - b. Sixteen (16) colors.
    - c. Sixty (60) outputs of dynamic data per graphic.
    - d. 1,000 separate graphic pages.
  - 5. Alarm Processing:
    - a. Off normal condition: Cause alarm and appropriate message.
    - b. Critical alarm or change-of-state: Display message, stored on disk for review and sort, or print.
    - c. Display alarm reports on video.
    - d. Allow unique routing of specific alarms.
    - e. Operator specifies if alarm requires acknowledgement.

6. Automatic Restart: Automatically restart field equipment on restoration of power. Provide time delay between individual equipment restart and time of day start/stop.
7. Maintenance Management: Run time monitoring and maintenance scheduling targets with scheduling.

B. Load Control Programs

1. General: Support inch-pounds and S.I. metric units of measurement.
2. Demand Limiting: Monitor total power consumption per power meter and shed associated loads automatically to reduce power consumption to an operator set maximum demand level.
3. Duty Cycling: Periodically stop and start loads, based on space temperature, and according to various On/Off patterns.
4. Automatic Time Scheduling: Automatic start/stop/scheduling of building loads.
5. Start/Stop Time Optimization: Perform optimized start/stop as function of outside conditions, inside conditions, or both.
6. Night Setback/Setup Program: Reduce heating space temperature setpoint or raise cooling space temperature setpoint during unoccupied hours; in conjunction with scheduled start/stop and optimum start/stop programs.

C. HVAC Control Programs

1. General: Support inch-pounds and S.I. metric units of measurement.
2. Optimal run time.
3. Supply air reset.
4. Enthalpy switchover.
5. Chiller control programs: Control function of condenser water reset, chilled water reset, and chiller sequencing.

## 2.3 AIR SUPPLY

B. Compressor and Receiver:

1. Manufacturer: [ ] Model [ ].
2. Other acceptable manufacturers offering equivalent products.
  - a. [ ] Model [ ].
  - b. [ ] Model [ ].
  - c. [ ] Model [ ].
  - d. Substitutions: [Permitted.] [Not permitted.]
3. [Simplex] [Duplex] belt driven air compressor with side seals, and tank unit with belt guard, silencers, flexible connections, air filter, automatic and manual drain assemblies, oil and particle filter for minimum 0.5 micron particles, pressure reducing valves, and pressure relief valves.
4. Size [each] compressor and storage tank to limit compressor starts to maximum [10] [ ] per hour and [50] [30] percent running time.
5. Electrical Alternation Set: With motor starters to operate compressors [alternately] [on time schedule].

B. Control and Instrumentation Tubing

1. Copper Tubing: Type ACR, or Type K, seamless, hard drawn or annealed.
  - a. Fittings: Wrought copper or brass.

- b. Joints: [Solder, 95-5] [Braze] or compression type.
  - 2. Polyethylene Tubing: Black, flame retardant, virgin polyethylene.
    - a. Fittings: UL labeled, rod or forged brass.
    - b. Joints: Compression or barbed type.
- B. Refrigerated Air Dryer: Self-contained, commercial quality, refrigerated, compressed air dryer complete with heat exchangers, moisture separator, and internal wiring and piping. Provide air inlet and outlet connections connected through manual by-pass valve. Operating to maintain dew point of 5 degrees F (-15 degrees C).

## 2.3 CONTROL PANELS

- B. Unitized cabinet type for each system under automatic control with relays and controls mounted in cabinet and temperature indicators, pressure gages, pilot lights, push buttons and switches flush on cabinet panel face.
- B. NEMA 250, general purpose utility enclosures with enamelled finished face panel.
- B. Provide common keying for all panels.

## 2.3 CONTROL VALVES

- B. Globe Pattern:
  - 1. Manufacturer: [ ] Model [ ].
  - 2. Up to 2 inches (50 mm): Bronze body, bronze trim, rising stem, renewable composition disc, screwed ends [with backseating capacity repackable under pressure].
  - 3. Over 2 inches (50 mm): Iron body, bronze trim, rising stem, plug-type disc, flanged ends, renewable seat and disc.
  - 4. Rate for service pressure of 125 psig at 250 degrees F (860 Kpa at 121 degrees C).
  - 5. Size for [3 psig (20 Kpa)] [ ] psig ( [ ] Kpa)] maximum pressure drop at design flow rate.
- B. Butterfly Pattern:
  - 1. Manufacturer: [ ] Model [ ].
  - 2. Iron body, [bronze] [aluminum bronze] [stainless steel] disc, resilient replaceable seat for service to [180 degrees F (82 degrees C)] [250 degrees F (121 degrees C)] wafer or lug ends, extended neck.
  - 3. Rate for service pressure of 125 psig at 250 degrees F (860 Kpa at 121 degrees C).
  - 4. Size for [1 psig (7 Kpa)] [ ] psig ( [ ] Kpa)] maximum pressure drop at design flow rate.
- B. Pneumatic Operators:
  - 1. Manufacturer: [ ] Model [ ].

2. Rolling diaphragm, spring loaded, piston type with spring range [2 to 5 psig (15 to 35 Kpa)] [3 to 10 psig (20 to 70 Kpa)] [8 to 11 psig (55 to 75 Kpa)] [as scheduled].
3. Valves shall spring return to normal position as indicated on freeze, fire, or temperature protection.

B. Electronic Operators:

1. Manufacturer: [ ] Model [ ].
2. Valves shall spring return to normal position as indicated on freeze, fire, or temperature protection.

B. Radiation Valves:

1. Manufacturer: [ ] Model [ ].
2. Bronze body, bronze trim, 2 or 3 port as indicated, replaceable plugs and seats, union and threaded ends.
3. Rate for service pressure of 125 psig at 250 degrees F (860 Kpa at 121 degrees C).
4. Size for [3 psig (20 Kpa)] [ ] psig ( [ ] Kpa)] maximum pressure drop at design flow rate.
5. Operators (2 Position): Synchronous motor with enclosed gear train, dual return springs, valve position indicator; 24 V dc, 0.4 amp. Valves shall spring return to normal position for temperature protection.
6. Operators (Modulating): Self contained, linear motorized actuator with approximately 3/4 inch (19 mm) stroke, 60 second full travel with transformer and SPDT contacts: 24 V dc, 6 watt maximum input.

## 2.3 DAMPERS

- B. Frames: [Galvanized steel] [Extruded aluminum] [Rolled carbon steel] [Stainless steel], welded or riveted with corner reinforcement.
- B. Blades: [Galvanized steel] [Extruded aluminum] [Rolled carbon steel] [Stainless steel], maximum blade size [8 inches (200 mm)] [ ] inches ( [ ] mm)] wide, 48 inches ([1200 mm) long, attached to minimum 1/2 inch (13 mm) shafts with set screws.
- B. Blade Seals: [Synthetic elastomeric] [Neoprene] [inflatable] mechanically attached, field replaceable.
- B. Jamb Seals: Spring stainless steel.
- B. Shaft Bearings: [Oil impregnated sintered bronze] [Graphite impregnated nylon sleeve, with thrust washers at bearings] [Lubricant free, stainless steel, single row, ground, flanged, radial, antifriction type with extended inner race].
- B. Linkage Bearings: [Oil impregnated sintered bronze] [Graphite impregnated nylon].
- B. Leakage: Less than [one] [1/2] percent based on approach velocity of 2000 ft/min (10 m/sec) and 4 inches wg (1.0 Kpa).



- B. Maximum Pressure Differential: 6 inches wg (1.5 Kpa).

## 2.3 DAMPER OPERATORS

- B. General: Provide smooth proportional control with sufficient power for air velocities 20 percent greater than maximum design velocity and to provide tight seal against maximum system pressures. Provide spring return for two position control and for fail safe operation.
- B. Pneumatic Operators: Rolling diaphragm piston type [with adjustable stops].
- B. Pilot Positioners: Starting point adjustable from 2 to 12 psig (15 to 83 Kpa) and operating span adjustable from 5 to 13 psig (35 to 90 Kpa).
- B. Electric Operators: Spring return, adjustable stroke motor having oil immersed gear train, with [auxiliary end switch] [minimum position potentiometer] [and 24 V dc, 24 va transformer].
- B. Inlet Vane Operators: High pressure with pilot positioners and sufficient force to move vanes when fan is started with vanes in closed position. Return vane operator to closed position on fan shutdown.

## 2.3 HUMIDISTATS

- B. Room Humidistats: Wall mounted, proportioning type, with cover with [set point indication] [concealed setpoint].
- B. Limit Duct Humidistat: Insertion type, two position.

## 2.3 INPUT/OUTPUT SENSORS

- B. Temperature:
  - 1. Manufacturer: [ ] Model [ ].
  - 2. Resistance temperature detectors with insertion or averaging elements in ducts and insertion elements for liquids with brass socket.
  - 3. Room sensors: Locking cover [matching the pneumatic thermostats used].
  - 4. Outside air sensors: Watertight inlet fitting, shielded from direct rays of sun.
  - 5. Room security sensors: Stainless steel cover plate with insulated back and security screws.
- B. Humidity Sensors:
  - 1. Manufacturer: [ ] Model [ ].
  - 2. Elements: Accurate within 5 percent full range with linear output.
  - 3. Room Sensors: With locking cover matching pneumatic thermostats.
  - 4. Duct and Outside Air Sensors: With element guard and mounting plate.
- B. Static Pressure Sensors:
  - 1. Manufacturer: [ ] Model [ ].

2. Unidirectional with ranges not exceeding 150 percent of maximum expected input, temperature compensated with one percent of full scale accuracy.

B. Equipment Operation Sensors:

1. Manufacturer: [ ] Model [ ].
2. Status Inputs for Fans: Differential pressure switch.
3. Status Inputs for Pumps: Differential pressure switch.
4. Status Inputs for Electric Motors: [Auxiliary contactor] [Current sensing relay with current transformers].

B. Digital to Pneumatic Transducers:

1. Manufacturer: [ ] Model [ ].
2. Convert [plus or minus 12 vdc pulse width modulation outputs] [continuous proportional current or voltage] to 0 to 20 psi (0 to 138 kPa).

B. Damper Position Indication: Potentiometer mounted in enclosure with adjustable crank arm.

B. Carbon Monoxide Detectors:

1. Manufacturer: [ ] Model [ ].
2. Single or multichannel dual level detectors, using solid state sensors with three year minimum life. Sensor replacement shall take maximum 15 minutes. Suitable over temperature range of 23 to 130 degrees F (-5 to 55 degrees C).

## 2.3 THERMOSTATS

B. Pneumatic Room Thermostats:

1. Adjustable proportioning type, [single] [dual] setpoint, containing [single bimetallic element for heating or cooling only] [dual bimetallic elements for] [heating and cooling] [day or night],
2. Covers: Locking with [set point adjustment] [setpoint indication] [concealed setpoint], [with thermometer] [without thermometer].

B. Electric Room Thermostats:

1. Manufacturer: [ ] Model [ ].
2. Type: NEMA DC 3, 24 volts[, with setback/setup temperature control].
3. Covers: Locking with [set point adjustment] [setpoint indication] [concealed setpoint], [with thermometer] [without thermometer].

B. Line Voltage Thermostats:

1. Manufacturer: [ ] Model [ ].
2. Integral manual On/Off/Auto selector switch, single or two pole as required, rated for motor load.
3. Cover: Locking with [set point adjustment] [setpoint indication] [concealed setpoint], [with thermometer] [without thermometer].

B. Outdoor Reset Thermostat:

1. Manufacturer: [ ] Model [ ].

2. Remote bulb or bimetal rod and tube type, proportioning action with adjustable throttling range, adjustable setpoint.

B. Electric Limit Duct Thermostat:

1. Manufacturer: [ ] Model [ ].
2. Snap acting, single pole, single throw, [manual] [automatic] reset switch which trips if temperature sensed across any 12 inches (300 mm) of bulb length is equal to or below setpoint,

B. Heating/Cooling Valve Top Thermostats:

1. Manufacturer: [ ] Model [ ].
2. Proportional acting for proportional flow, molded rubber diaphragm, [remote bulb] liquid filled element, direct and reverse acting at differential pressure to 25 psig (172 kPa), cast housing with position indicator and adjusting knob.

## 2.3 TIME CLOCKS

B. [ ] Model [ ].

- B. Seven day programming switch timer with synchronous timing motor and seven day dial, continuously charged Ni-cad battery driven power failure 8 hour carry over and multiple switch trippers to control systems for minimum of two and maximum of eight signals per day with two normally open and two normally closed output switches.

- B. Solid state programmable time control with [ ] separate programs, 24 hour battery carry over [duty cycling] [individual on/off/auto switches for each program] [7 day programming] [365 day calendar with 20 programmable holidays] [choice of fail safe operation for each program] [system fault alarm].

## 2 PART - EXECUTION

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### 3.3 EXAMINATION AND PREPARATION

- B. Verify that conditioned power supply is available to the panels and to the operator work station. Verify that field end devices, wiring, and pneumatic tubing is installed prior to installation proceeding.
- B. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

## 2.3 INSTALLATION

- B. Install Work in accordance with manufacturer's instructions.
- B. Provide conduit and electrical wiring where required. Refer to Section 16180.
- B. After completion of installation, test and adjust control equipment. Submit data showing set points and final adjustments of controls.

- B. Install panels and other hardware in position on permanent walls where not subject to excessive vibration.
- B. Install software in panels and in operator work station. Implement all features of programs to specified requirements and appropriate to sequence of operation.
- B. Mount compressor and tank unit on vibration isolation [consisting of springs, with minimum 2 inches (50 mm) static deflection and one inch (25 mm) clearance to floor. Pipe manual and automatic drains to nearest floor drain.
- B. Supply instrument air from compressor units through filter, pressure reducing valve, pressure relief valve, with pressure gages, and shutoff and bypass valves.
- B. Use copper tubing in mechanical rooms, where subject to damage or temperatures where adjacent to heating pipes passing through common sleeve, and where not readily accessible. Conceal tubing.
- B. Provide instrument air tubing with check and hand valves to expansion tanks with Schraeder fittings and hose.
- B. Check and verify location of thermostats [humidistats] and other exposed control sensors with plans and room details before installation. Locate 60 inches (1 500 mm) above floor. Align with lighting switches.
- B. Provide guards on thermostats in entrances [and other public areas] [and where indicated].
- B. Provide mixing dampers of [opposed] [or] [parallel] blade construction arranged to mix streams. Provide pilot positioners on mixed air damper motors. [Provide separate minimum outside air damper section adjacent to return air dampers with separate damper motor.]
- B. Install damper motors on outside of duct in warm areas. Do not install motors in locations at outdoor temperatures.
- B. Install "hand/off/auto" selector switches to override automatic interlock controls when switch is in "hand" position.
- B. Provide conduit and electrical wiring in accordance with appropriate requirements of Division 16.

## 2.3 CABINET HEATERS

- B. Single temperature [electric] [room] [pneumatic] thermostat [mounted in cabinet return air] set at [68 degrees F (20 degrees C)] [ ] degrees F ( [ ] degrees C)] maintains constant space temperature by cycling unit fan motor.

- B. Single temperature thermostat on return heating water line [from floor mounted cabinet heaters] de-energizes unit on temperatures below [95 degrees F (35 degrees C)] [\_\_\_\_] degrees F ([\_\_\_\_] degrees C)].

## 2.3 CENTRAL REFRIGERATION SYSTEM

- B. Time Schedule: Start and stop condensing water pump.
- B. Condensing Water Pump: Allow start on proof of water in cooling tower sump and on outdoor temperature above [50 degrees F (10 degrees C)] [\_\_\_\_] degrees F ([\_\_\_\_] degrees C)]. [Start on demand from ventilation system.]
- B. Energize chilled water pump to start and allow cooling tower fans to start when condensing water pump started.
- B. When chilled water pump starts, open chiller control valve. Modulate chiller control valve to maintain constant flow through chiller.
- B. When chilled water flow and condensing water flow are proven by flow switches, allow refrigeration machine to start.
- B. Maintain minimum condenser water temperature of [55 degrees F (13 degrees C)] [75 degrees F (24 degrees C)] [\_\_\_\_] degrees F ([\_\_\_\_] degrees C)] by cycling cooling tower fans.
- B. Maintain temperature in cooling tower sump of 40 degrees F (4.5 degrees C) by cycling electric sump heaters. Outdoor thermostat set at [35 degrees F (2 degrees C)] [\_\_\_\_] degrees F ([\_\_\_\_] degrees C)] shall activate electric heat tapes.
- B. Thermostat in cooling tower sump, set at [35 degrees F (2 degrees C)] [\_\_\_\_] degrees F ([\_\_\_\_] degrees C)], open drain lines, closes make-up valve, and deactivates sump heaters and piping electric heat tapes.
- B. Display:
  - 1. System graphic.
  - 2. Condensing water pump on/off indication.
  - 3. Chilled water pump on/off switch.
  - 4. Chiller on/off indication.
  - 5. Chiller condensing water supply and return temperature.
  - 6. Chiller chilled water supply and return temperature.
  - 7. Chiller condensing water control point adjustment.
  - 8. Common chilled water control point adjustment.
  - 9. Low level cooling tower sump alarm.
  - 10. Expansion tank low level alarm.
  - 11. Cooling tower fan on/off indication.
  - 12. Cooling tower sump heater on/off indication.
  - 13. Cooling tower dump indication.
  - 14. Chilled water control point adjustment.

## 2.3 CENTRAL FAN SYSTEM

- B. Time Schedule: Start and stop supply and return fans. Determine fan status [through auxiliary contactors in motor starter] [by pressure differential switches] [by current sensing devices]. If fan fails to start as commanded, signal alarm.
- B. Safety Devices:
  - 1. Freeze Protection: Stop fans [and close outside air dampers] if temperature [before supply fan] [downstream of preheat coil] [and in preheat coil return line] is below 37 degrees F (3 degrees C); signal alarm.
  - 2. High Temperature Protection: Stop fans and close outside dampers if temperature in return air is above 300 degrees F (150 degrees C); signal alarm.
- 3. \*\*\* Smoke Detector: Stop fans, close outside dampers, and close smoke dampers if smoke is detected; signal alarm.
- B. Preheat Coil:
  - 1. When fan is not running, and outside air temperature is below 40 degrees F (5 degrees C), [fully] [partially] open preheat coil valve to heating.
  - 2. When fan is running, maintain constant [mixed air] [supply air] temperature of 55 degrees F (12 degrees C) by modulating preheat coil valve.
- B. Outside Air Damper: When supply fan is running, open outside air damper [to minimum position]. [Prevent supply fan starting until outside air damper is open and position is verified.]
- B. Humidifier: When supply fan is running allow humidifier to operate.

\*\*\*\*\* [OR] \*\*\*\*\*

- E. Humidifier: When supply fan is running [and there is water in humidifier sump], humidistat located in return air, reset from outdoors [modulates normally closed humidifier valve] [cycle spray pumps] [and modulates valve on spray header]. Set outdoor reset to 50 percent relative humidity at 70 degrees F (21 degrees C) and 15 percent relative humidity at -30 degrees F (-35 degrees C).
- E. Outside, Return, and Relief Dampers:
1. When supply fan is not running, outside and relief dampers are closed and return damper is open.
  2. When supply fan is running, dampers are controlled and operate with outside and relief dampers opening, and return damper closing.
  3. For cooling and outside air temperatures below 55 degrees F (12 degrees C), modulate dampers to maintain [mixed] [supply] air temperature of 55 degrees F (12 degrees C) [or higher].
  4. For cooling and outside air temperatures between 55 and 70 degrees F (12 and 21 degrees C) outside and relief dampers are open and return damper is closed.
  5. For cooling and outside air temperatures between 70 and 79 degrees F (21 and 26 degrees C) compare return and outside air temperatures. If return air temperature is lower, drive outside damper to minimum, close relief damper, and open return damper.
  6. For outside air temperatures above 79 degrees F (26 degrees C), drive outside damper to minimum, close relief damper, and open return damper.
  7. For heating, drive outside damper to minimum, close relief damper, and open return damper.
- E. Modulate [mixed air dampers] [preheat coil valve] [and face and bypass dampers] [and cooling coil valve] in sequence to maintain [constant] [mixed] [supply] air temperature.
- E. Multizone System:
1. [Space sensor] [[Single] [Dual] temperature room thermostat] set at [75 degrees F (24 degrees C)] [\_\_\_\_] degrees F ([\_\_\_\_] degrees C)] maintains constant space temperature [during the day and 15 degrees F (8 degrees C) cooler at night] by modulating zone dampers.
  2. Room calling for greatest heating modulates reheat coil valve. [Room thermostat calling for greatest cooling modulates cooling coil valve.]
- E. Dual Duct System:
1. Control hot deck temperature in accordance with outdoor reset schedule by modulating reheat coil valve.
  2. Control hot deck at maximum 135 degrees F (57 degrees C) at outdoor temperature of -30 degrees F (-35 degrees C), and minimum 75 degrees F (24 degrees C) at outdoor temperature of 75 degrees F (24 degrees C), with straight line relationship between.
  3. Maintain constant cold deck temperature of 55 degrees F (12 degrees C) by modulating cooling coil valve.

- E. Induction System:
1. Control hot deck temperature in accordance with outdoor reset schedule by modulating reheat coil valve.
  2. Control zone temperature at maximum 135 degrees F (57 degrees C) at outdoor temperature of -30 degrees F (-35 degrees C), and minimum 55 degrees F (12 degrees C) at outdoor [solar compensated] temperature of 75 degrees F (24 degrees C), with straight line relationship between, by modulating reheat coil valve.

- E. Maintain constant supply static pressure of [1.5 inches wg (380 Pa)] [\_\_\_\_\_] inches wg (\_\_\_\_\_] Pa) by modulating supply and return fan inlet vane dampers in sequence. Locate sensor minimum [50 ft (15 m)] [\_\_\_\_\_] ft (\_\_\_\_\_] m) downstream of supply fan in supply air duct.

\*\*\*\*\* [OR] \*\*\*\*\*

- K. Maintain constant supply static pressure of [1.5 inches wg (380 Pa)] [\_\_\_\_\_] inches wg (\_\_\_\_\_] Pa) by modulating supply fan inlet vane dampers. Maintain constant building pressure of [0.05 inches wg (12 kPa)] [\_\_\_\_\_] inches wg (\_\_\_\_\_] Pa) measured at grade by modulating return air fan inlet vane dampers.

\*\*\*\*\* [OR] \*\*\*\*\*



- K. Maintain constant supply static pressure of [1.5 inches wg (380 Pa)] [ ] inches wg ( Pa)] by modulating supply fan inlet vane dampers. Maintain constant differential air flow rate between supply and return by modulating return fan inlet vane dampers from velocity pressure measurements in supply and return ducts.

K. Display:

1. System graphic.
2. System on/off indication.
3. System day/night mode.
4. System fan on/off indication.
5. Return fan on/off indication.
6. Preheat coil pump on/off indication.
7. Spray pump on/off indication.
8. Outside air temperature indication.
9. Mixed air temperature indication.
10. Fan discharge air temperature indication.
11. Reheat zone air temperature indication.
12. Return humidity indication.
13. Fan discharge temperature control point adjustment.
14. Return humidity control point adjustment.
15. Reheat zone control point adjustment.
16. Supply static pressure indication.
17. Supply static pressure control point adjustment.
18. Building static pressure indication.
19. Building static pressure control point adjustment.

#### 4.6 COMBUSTION AIR UNIT HEATERS

- K. Single temperature room thermostat set at [68 degrees F (20 degrees C)] [ ] degrees F ( ] degrees C)] maintains constant room temperature by modulating [two-way] [three-way] heating control valve.

- K. Single temperature thermostat on return heating water line de-energizes unit fan on temperature below [95 degrees F (35 degrees C)] [ ] degrees F ( ] degrees C)].

#### 4.6 ELECTRICAL ROOMS AND TELEPHONE ROOMS

- K. On room temperatures above [95 degrees F (35 degrees C)] [ ] degrees F ( ] degrees C)] [open intake damper and] start [exhaust] fan.

#### 4.6 ELEVATOR MACHINE ROOM

- K. On room temperature above [85 degrees F (30 degrees C)] [ ] degrees F ( ] degrees C)], open intake dampers and start exhaust fans.

- K. On room temperatures above [90 degrees F (32 degrees C)] [ ] degrees F ( ] degrees C)], signal alarm.

#### 4.6 EMERGENCY GENERATOR

- K. When the generator not running, outside and exhaust dampers are closed and recirculation damper is open.
- K. When generator is running, dampers are controlled and operate with outside and exhaust dampers opening, and recirculating dampers closing, to maintain room temperature of [85 degrees F (30 degrees C)] [ ] degrees F ( ) degrees C).
- K. On room temperatures above [95 degrees F (35 degrees C)] [ ] degrees F ( ) degrees C)] open intake damper and start exhaust fan.
- K. Provide solenoid valve to shut off fuel supply when generator is not operating.

#### 4.6 EXCESS PRESSURE CONTROL

- K. Maintain constant pressure differential between supply and return lines by [modulating bypass valves] [cycling pumps in sequence] [varying pump speed through variable speed drive control].

#### 4.6 FAN COIL UNITS

- K. [Single] [Dual] temperature unit mounted thermostat set at [75 degrees F (24 degrees C)] [ ] degrees F ( ) degrees C)] maintains constant space temperature [during the day and [15 degrees F (8 degrees C)] [ ] degrees F ( ) degrees C)] cooler at night] by [modulating] [opening and closing] two-way control heating valve [with spring range of [3 to 7 psig (20 to 48 kPa)] [3 to 13 psig (20 to 90 kPa)]]].
- K. [Single] [Dual] temperature unit mounted thermostat set at [75 degrees F (24 degrees C)] [ ] degrees F ( ) degrees C)] maintains constant space temperature [during the day and [15 degrees F (8 degrees C)] [ ] degrees F ( ) degrees C)] cooler at night] by [modulating] [opening and closing] two-way control heating valve [with spring range of 3 to 7 psig (20 to 48 kPa)] [and two-way cooling control valve [with spring range of 8 to 13 psig (55 to 90 kPa)]] in sequence.
- K. [Single] [Dual] temperature unit mounted thermostat set at [75 degrees F (24 degrees C)] [ ] degrees F ( ) degrees C)] maintains constant space temperature [during the day and [15 degrees F (8 degrees C)] [ ] degrees F ( ) degrees C)] cooler at night] by modulating four-way control valve. During heating cycle, modulate hot water supply to coil and divert return modulate chilled water supply to coil and divert return water to cooling return pipe. When space temperature is at thermostat setting, prevent flow from occurring in either circuit and in coil.
- K. Change over from heating to cooling by indexing thermostat from thermostat on supply piping. When supply is above room temperature, operate thermostat in direct

acting manner, opening valve when temperature falls below thermostat setting. When supply is below room temperature, operate thermostat in reverse acting manner, opening valve when space temperature rises above thermostat setting.

- K. For heating and cooling fan coil units with fan speed control during heating cycle, increase fan speed as space temperature falls below thermostat setting, provided hot water is available. During cooling cycle, increase fan speed as space temperature rises above thermostat setting, provided chilled water is available.
- K. Mount thermostat with adjustable knob and speed switch on common plate engraved with "Heating Control and Fan Control" on top, with "Warmer and Cooler" and direction indicator around the thermostat knob.

#### 4.6 HEATING COILS

- K. [Single] [Dual] temperature thermostat set at [75 degrees F (24 degrees C)] [ ] degrees F ( ) degrees C] maintains constant space temperature [during the day and [15 degrees F (8 degrees C)] [ ] degrees F ( ) degrees C] cooler at night] by [modulating] [opening and closing] [two-] [three-] way control heating valve [with spring range of [3 to 7 psig (20 to 48 kPa)] [3 to 13 psig (20 to 90 kPa)]].
- K. Single temperature room thermostat set at [75 degrees F (24 degrees C)] [ ] degrees F ( ) degrees C] maintains constant space temperature by [energizing] [staging] [modulating electric output through action at SCR power controller, to] electric heaters.

#### 4.6 HEATING WATER ZONE CONTROL

- K. [Flow] [Pressure] switch in heating pump discharge provides on/off indication.
- K. Control heating water supply temperature set at [195 degrees F (90 degrees C)] [ ] degrees F ( ) degrees C]] [in accordance with outdoor reset schedule] by [modulating steam control valve] [modulating heating water control valve] [modular boiler gas valve] [step firing boilers].
- K. Control heating water at maximum [195 degrees F (90 degrees C)] [ ] degrees F ( ) degrees C] at outdoor temperature of [-30 degrees F (-35 degrees C)] [ ] degrees F ( ) degrees C], and minimum [130 degrees F (54 degrees C)] [ ] degrees F ( ) degrees C] at outdoor temperature of [75 degrees F (24 degrees C)] [ ] degrees F ( ) degrees C], with straight line relationship between.
- K. Step fire boilers in sequence, [Boiler No. 1 - low fire, Boiler No. 1 - high fire, Boiler No. 2 - low fire, Boiler No. 2 - high fire] [ ].
- K. [Flow] [Pressure] switch in heating water circuit on no flow conditions [closes valve and] indicates alarm.

K. On outside temperatures above [65 degrees F (18 degrees C)] [\_\_\_\_] degrees F ([\_\_\_\_] degrees C)], de-energize heating pumps and suppress alarm.

K. Display:

1. System graphic.
2. System supply temperature.
3. System supply control point adjustment.
4. System return temperature.
5. Pump on/off indication

#### 4.6 HUMIDIFIER

K. When fan is running [and air flow switch proves air flow], line voltage room humidistat [reset from outdoors] maintains humidity level of [30] [\_\_\_\_] percent by [cycling unit fan and] [opening two position] [modulating] two-way [steam] [hot water] valve.

K. When supply fan is running [and air flow switch proves air flow] [and there is water in humidifier sump], humidistat located in return air, reset from outdoors [modulates normally closed humidifier valve] [cycle spray pumps] [and modulates valve on spray header]. Set outdoor reset to [50] [\_\_\_\_] percent relative humidity at [70 degrees F (2 degrees C)] [\_\_\_\_] degrees F ([\_\_\_\_] degrees C)] and [15] [\_\_\_\_] percent relative humidity at [-30 degrees F (-35 degrees C)] [\_\_\_\_] degrees F ([\_\_\_\_] degrees C)].

#### 4.6 INDUCTION UNITS

K. [Single] [Dual] temperature unit mounted thermostat maintains constant space temperature at [75 degrees F (24 degrees C)] [\_\_\_\_] degrees F ([\_\_\_\_] degrees C)] [during the day and [60 degrees F (16 degrees C)] [\_\_\_\_] degrees F ([\_\_\_\_] degrees C)] cooler at night] by [modulating] [opening and closing] two-way control heating valve [with spring range of [3 to 7 psig (20 to 48 kPa)] [3 to 13 psig (20 to 90 kPa)] [8 to 13 psig (55 to 90 kPa)]]].

#### 4.6 PARKING GARAGE VENTILATION SYSTEM

K. Time Schedule: Stop exhaust fan at night.

K. Carbon Monoxide (CO) detector maintains maximum CO level of 50 ppm by cycling exhaust fan. When CO level exceeds 100 ppm, signal alarm.

K. When exhaust fan starts, start make-up unit.

#### 4.6 RADIANT PANEL

K. [Single] [Dual] temperature set at [75 degrees F (24 degrees C)] [\_\_\_\_] degrees F ([\_\_\_\_] degrees C)], by [modulating] [opening and closing] two-way control heating valve [with spring range of [3 to 7 psig (20 to 48 kPa)] [3 to 13 psig (20 to 90 kPa)]]].

- K. [Single] [Dual] temperature thermostat set at [75 degrees F (24 degrees C)] [ ] degrees F ( ) degrees C] shall maintain constant space temperature [during the day and [15 degrees F (8 degrees C)] [ ] degrees F ( ) degrees C] cooler at night] by modulating four-way control valve. During heating cycle, modulate hot water supply to coil, and divert return water to heating return pipe. During cooling cycle, modulate chilled water supply to coil and divert return water to chilled water supply to coil and divert return water to cooling return pipe. When space temperature is at thermostat setting, prevent flow from occurring in either circuit and in coil.

- K. Change over from heating to cooling by indexing thermostat from aquastat on supply piping. When supply is above room temperature, operate thermostat in direct acting manner, opening valve when temperature falls below thermostat setting. When supply is below room temperature, operate thermostat in reverse acting manner, opening valve when space temperature rises above thermostat setting.

#### 4.6 RADIATION [AND CONVECTORS]

- K. [Single] [Dual] temperature thermostat set at [75 degrees F (24 degrees C)] [ ] degrees F ( ) degrees C] maintains constant space temperature [during the day and [15 degrees F (8 degrees C)] [ ] degrees F ( ) degrees C] cooler at night] by [modulating] [opening and closing] two-way control heating valve [with spring range of [3 to 7 psig (20 to 48 kPa)] [3 to 13 psig (20 to 90 kPa)]]].

- K. Single temperature room thermostat set at [75 degrees F (24 degrees C)] [ ] degrees F ( ) degrees C] maintains constant space temperature by [energizing] [staging] [modulating electric output through action at SCR power controller, to] electric heaters.

#### 4.6 REFRIGERATION SYSTEM.

- K. Maintain constant [supply] [return] air duct temperature of [55 degrees F (13 degrees C)] [75 degrees F (24 degrees C)] [ ] degrees F ( ) degrees C] by cycling refrigeration system and signalling step capacity, minimum of [ ] steps.

#### 4.6 TERMINAL AIR UNITS

- K. [Single] [Dual] temperature thermostat set at [75 degrees F (24 degrees C)] [ ] degrees F ( ) degrees C] maintains constant space temperature [during the day and [15 degrees F (8 degrees C)] [ ] degrees F ( ) degrees C] cooler at night] by [modulating] [opening and closing] two-way control heating valve [with spring range of [3 to 7 psig (20 to 48 kPa)] [3 to 13 psig (20 to 90 kPa)]]].

- K. [Single] [Dual] temperature thermostat set at [75 degrees F (24 degrees C)] [ ] degrees F ( ) degrees C] maintains constant space temperature by modulating [variable volume damper] [and] [dual duct damper] operator.

- K. Where reheat coils or radiation is also provided, sequence two-way heating control valve with damper operator [having spring range of 8 to 13 psig (55 to 90 kPa)].

#### 4.6 UNIT HEATERS

- K. Single temperature electric room thermostat maintains constant space temperature of [68 degrees F (20 degrees C)] [ ] degrees F ( ] degrees C)] by cycling unit fan motor.
- L. Single temperature thermostat on return heating water line [from floor mounted cabinet heaters] de-energizes unit on temperatures below [95 degrees F (35 degrees C)] [ ] degrees F ( ] degrees C)].
- K. Single temperature room thermostat set at [68 degrees F (20 degrees C)] [ ] degrees F ( ] degrees C)] maintains constant space temperature by cycling unit fan motor and energizing electric heating elements. [Integral thermostat continues fan operation until element temperature falls below [100 degrees F (38 degrees C)] [ ] degrees F ( ] degrees C)].]

**END OF SECTION 15950**